

Higher Education Systems and Industrial Innovation¹
An interactive analysis involving actors, organizations and societal conventions

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Summary

This text discusses the approach adopted in a European research project concerning the relationships between science and industry. The analysis uses the notion of actors as vectors for the creation and diffusion of competences and knowledge throughout the innovation process. From this perspective, the article presents some results on the strategic behaviour of firms at the micro-level in five countries. An analytical framework in terms of “conventions” addresses the interplay between micro and macro levels. Finally, we present some significant insights into national public policies in the field of science-industry collaboration.

Key words

Science-industry; knowledge creation; learning; institutions; state intervention; policy-making

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Introduction

In the present process of economic globalization, the quality and intensity of relationships between science and industry are often regarded as major factors on which industrial innovation and economic competitiveness depend. In this context, higher education systems, namely universities and public research laboratories, have a central role (Etzkowitz et al., 1997) within the core of interactive innovation processes: scientific activities are influenced by technological innovation and in turn influence the innovative activities of firms. This provides the basis for economic competitiveness, the development of new competences and societal wealth generation (Lundvall and Johnson, 1994). In this context, the main objective of the SESI project was to gather empirical evidence about effective ways of organizing the linkages and interfaces between higher education institutions and private-sector firms, in order to optimize the flow of knowledge and information between them and thereby spur on industrial innovation. In the social sciences since Durkheim, the comparative empirical approach has been employed as an appropriate way to discover any causal relationships between different phenomena: thus empirical data was collected from about fifty case studies of Science-Industry collaborations conducted in five European countries (Austria, France, Germany, Portugal and the United Kingdom).

There are considerable differences amongst OECD countries, in the way this interaction between science and industry occurs (Laredo, Mustar 2001). Such national differences in the innovation process have also been clearly acknowledged by national innovation systems theorists (Lundvall 1992). The approach adopted for this project presents some strong similarities with this institutional analysis but in addition gives a crucial analytical role to the notion of actors (Maurice, Sorge 2000) as vectors for the creation and diffusion of competences and knowledge throughout the innovation process.

The main dimension of the project concerned the relations between actors from two different worlds - higher education and firms - which are differently configured in each country and do not necessarily have convergent goals. It was decided to focus on firms' behaviour in the organisation of R&D activities and particularly on the practices adopted in cooperating with higher education. From this perspective two major social phenomena had to be investigated.

The first one was technological innovation, regarded as a process that unfolds within the dynamics of particular industries or sectors. Taking Pavitt's typology (1984) as its point of departure, the project set out to analyse the consequences of the emergence of new technological systems, the emblematic examples being biotechnology and the convergence of information technology and telecommunications. The analysis thus attempted to frame the process of innovation, to identify the organisational and institutional factors which favoured efficient collaboration between academia and industry.

The second dimension was the dynamic of the linkages between the global and local: to what extent do firms' strategies affect scientific and technological organisation and policies, both nationally and locally? Similarly, what opportunities do national institutional infrastructures provide for companies and their practices? To answer such questions, we used the notion of "societal convention" (Verdier, 1999), which supports the coordination between the micro-strategies of firms and universities on the one hand, and the meso- and macro-policies of the public authorities in the fields of science and innovation on the other. This analysis which is both multi-level and actor related converges to some extent with "actor centred institutionalism" (Scharpf, 1997), most notably where it underlines the effect of institutional conditions as contingent on the normative and cognitive orientations of the actors involved in policy making (Scharpf, 2000).

The first section of this text discusses the approach to innovation adopted in the SESI project. The second section delivers some results concerning the strategic behaviour of firms at the micro-level. The third presents an analytical framework in terms of "conventions" for dealing with the interplay between micro and macro levels. Finally the fourth section offers some significant insights into national trajectories of public policy-making in the domain of science-industry collaboration.

I - A dynamic approach to innovation: interaction between actors, institutions and organisations.

Innovation is self-evidently multidimensional and goes hand in hand with changes in the organisations and institutions in which the actors' strategies unfold. This is why any partial approach to innovation, focusing, for example, on the strategy pursued by any one of the actors involved, remains incomplete, since very little in the way of general lessons can be derived from it. At the same time, holistic approaches to innovation do little to take into account the multi-dimensional characteristics of innovation. Such approaches frequently lead to a rigidly defined institutional environment to guide the decisions of the actors, who are reduced in consequence to mere agents (Mansfield, Lee 1996); as a result, they take into account only a fraction of the actor's coordinates for developing an interactive learning behaviour: he is seeking to solve problems and redefine his system of constraints before eventually managing, more or less convincingly, the reconstruction of his action system, which then interacts with an environment made up of organisations and institutions.

The definition of innovation adopted in this project derives from evolutionary and societal analysis (Lanciano, Maurice, Nohara, Silvestre, 1998). Innovation is regarded as the outcome of a twofold process whereby resources are created and also appropriated by firms, which then construct an innovation system embedded in local, national and international contexts. Picking up on Lundvall's work in this field (1992), the main point here is no longer the process of calculation and decision-making but the process of learning and creating complex bodies of knowledge within innovation dynamics. These include not only firms' internal processes but also the interaction between firms and public R&D organisations as well as education and training institutions. In this sense, an innovation system can be conceived as a locus where the dynamics of learning – the absorption of resources by firms- are forged by the interaction between the actors' competence formation and the inter-organizational fertilization.

For a firm, innovation encompasses a number of processes - technical, organisational, institutional and cognitive - all contributing to technology design and development. However, it also has two additional defining characteristics.

Firstly, innovation constitutes a firm's specific capacity to construct its stocks of knowledge and competences, its relationship with technology and the practices it adopts in its cooperation with its industrial and academic environment (Gaffard, 1990). The outcome of these processes, particularly in multinational firms, is a truly distinctive capacity for generating technological and organisational resources in a bid for global competitiveness.

Secondly, a firm constructs its innovation space by interacting with the industrial and institutional environment. To innovate, it must choose and acquire the resources, which it lacks but deems necessary. In order to appropriate these resources and utilise them effectively for its own development, it will specify them according to particular needs, with the aim of converting them into innovative routines (Dosi, Nelson, 1994) that cannot be purchased in the current market. Thus firms are faced with a permanent tension between the preservation of routines that construct order and maintain knowledge and know-how as a coherent whole, on the one hand, and the search for new routines that might produce renewal on the other. In other words, firms are not only structures for the management and accumulation of specific knowledge but also entities endowed with rules which govern their functioning and embody the collective lessons learnt in the course of their history, and with rules which govern their development and through which new knowledge can be acquired (Granovetter, 1985).

Depending on the capacities built up over time and their ability to evolve, research and higher education establishments enable firms to explore more or less rapidly the opportunities offered by the emergence of new technological and scientific fields. This is what is meant by the "embeddedness" of the strategies of the various innovative actors operating within an organisational, social and economic context. The question of knowing to what extent actors' choice is context- dependent is especially pertinent to this project. In other words, to what extent can a firm's strategy be related to a particular - local or national - innovation system? Can innovation systems still be defined on a national basis? What impact do the strategies of multinational companies - and for that matter those of "research universities" - have on national R&D institutions in the perspective of innovation?

Finally, as the triple helix approach (Etzkowitz H, Leydesdorf L, 2000) suggests, it is important to take into account the public policies that contribute to the definition of national forms of innovation systems.

II - Science-industry relations: the organizational and institutional factors of effective collaboration at the micro-level

The quality of science-industry relations in a given country is determined by the ways in which the specific interests of academia and firms are rendered compatible. All science-industry collaborations presuppose the existence of institutional structures that favour the convergence of objectives or require the creation of ad-hoc institutions, both for organisational purposes and to provide common points of reference for the actions of the various protagonists. Two main factors, both linked to the definition of intellectual property rights, were analysed: the compatibility of the research agendas and the devices for favouring the convergence of interests.

The initial challenge: the cognitive and cultural "gaps" between "science" and "industry"

The literature provides many opportunities to identify the disparities between the two worlds of scientific research and industry, whose members pursue very different objectives, are motivated by very different forms of incentive and are subject to very different evaluation procedures. The objective then becomes one of reducing or managing these differences by closing the gap between the two worlds while at the same time ensuring that this reduction of disparities does not diminish the mutual gains derived from collaboration, thereby seriously undermining the aims of the exercise. The notion of "gap" can be extended beyond the cognitive dimension to encompass more cultural aspects as well. The two kinds of gaps may be traceable back to the output of the training and education system. Notably they are closely linked to the specificities of the various "national models" and in particular, to the configuration of the engineering and research professions in each country (Lanciano-Morandat, Nohara, 2003).

Undoubtedly too great a cognitive gap increases transaction and coordination costs and thereby reduces the incentive for firms and research academic units to cooperate. From a classification of almost fifty cases of collaboration, two models of research agenda compatibility (Carayol, 2003) seem to emerge, in which the overall strategies of the academic and industrial actors tend to produce a common response to technological risk. This is underpinned by a coherent set of functional and specialised principles.

In the first model, firms benefit from research at a relatively low cost and in an integrated and systematic way, while the academic partner's main concern is to maximise the volume of research. The latter pools information on firms' needs and codifies their technical problems in order to provide standard scientific responses. There is a relatively low level of technical risk here, and the commercial risk is mitigated by a close-knit collaborative network. This is a generalised version of Kline and Rosenberg's chain-linked model (1986), in which the technology is no longer appropriated autonomously by the firm's research laboratory. In terms of the practicalities of cooperation, the rules whereby cooperation is managed must enable the partners to face and respond effectively to the classic problems of balancing risks and incentives. To this end, the research establishment or university involved can help to spread the risk by adopting a form of contract which combines fixed payments with deferred payments that are dependent on the returns to the knowledge produced in the course of the collaboration.

In the second model, the academic partner's research agenda remains in place, the aim here being to advance knowledge in a clearly defined field of scientific excellence. As far as the industrial partner is concerned, the objective is to tackle a promising area of research in order to open up a significant lead over rivals. The much greater level of technical risk is mitigated by a "self-protective" approach, which reduces the probability of failure by making academic excellence the principal criterion for choosing academic partners.

This tendency towards bipolarisation among higher education establishments on the basis of their functional specialisation - with the leading establishments seeking to become major players in the

"knowledge market" and the less prestigious ones providing support for firms and undertaking contract research, is not, however, inevitable or necessarily desirable.

This basic matching mechanism is complementary to a realistic typology of collaborative strategies that takes into account the diversity of Science-Industry relationships observed in our field studies.

The devices underlying industry-science linkages : the relative value of intermediate actors

The Science-Industry relations are diverse and increasingly targeted at specific objectives. Three types of collaboration strategies could be identified:

The "portfolio management" strategy leads the partners to look for a relatively simple organisational design in order to coordinate essentially bilateral relations between independent organisations. A high level of flexibility produces considerable capacity for adaptation, the task of coordination being entrusted to "gatekeepers"², which makes it possible to absorb risk by confining it to the boundaries of each organisation.

The second is a strategy of "embedding" industry-science relations in the two partners' organisational and management structures. This makes it possible to establish various hybrid entities, such as mixed research units, bilateral long-term agreements, joint platforms, consortia involving firms and higher education systems. This type of relation tends to minimise the tensions between academia and firms in restricting the irreversibilities that impair each partner's ability to cause or initiate collaboration.

A third strategy involves the use of an already constituted "intermediate actor" to fill the gap in knowledge levels and fields of specialisation that may separate the partners. The example most frequently encountered in our sample is the creation of a spin-off from a Higher Education and Research unit, although firms can also set up the same kind of entity under virtually identical conditions. It may lead ultimately to the creation of a hybrid collective actor or of an institutionalised collective actor, independent of the partners. The intervention of an intermediate organisation subject to its own rule and value system contributes to the externalisation of the risk inherent in the science-industry relations. Nevertheless it is far from immune from the possibility of failure, particularly because of excessively wide cognitive gaps and/or disparate strategies.

These gaps, and the ensuing adjustment costs, can be reduced by exploiting the opportunities that exist for establishing "bridges" between the two worlds and through mobility of personnel. Such mobility helps to activate and strengthen complementarities between the actors and to diffuse knowledge and is also an important channel for technology transfers. Thus the hybrid actors, the so-called "gatekeepers", facilitate the coordination of relations and the management of possible cognitive gaps by establishing continuity between the various forms of knowledge produced by the partners.

III - Systems of innovation as collective action based on conventions

In order to understand infra-national diversity and institutional dynamics, it is necessary to identify the different types of public interventions – from local to national – in which the various criteria (efficiency, legitimacy etc.) are embedded. In this particular field, the public and private actors involved in regulating national systems base their interventions on a set of public policy-making conventions (Lanciano-Morandat, Verdier, 2004).

These conventions are the basis for the legitimacy of rules. They encompass different conceptions of what is "efficient and fair" in policy-making concerning research, development and innovation (RDI). Each of them corresponds to a specific mode of justification or to a particular research ethic (Boltanski, Thévenot, 1991): scientific progress; State service and the national interest; the market, i.e. the creation of shareholder value; and, lastly, the project embodying technological creativity (Boltanski and Chiappello, 1999).

Explicit reference to the state's position in collective action makes it possible to identify four conventions: the "republic of science", the "state as entrepreneur", the "state as regulator" and, finally,

² For instance, academic consultants working with firms or students forced by the absence of grants to fund their studies by taking temporary jobs in high tech firms.

the "state as facilitator" (of technological projects). There are many points in common with the approach developed by Storper and Salais (1997) in terms of conventions denoted by terms such as the "absent state" (particularly marked in the US), the "external state" (or "overarching state", strong in France) and the "situated or subsidiary state" (of which Germany is the archetype).

These conventions cannot be dissociated from the following dimensions that constitute the RDI policy-making regime in which they are situated:

- the positioning of the public authorities in a multi-level perspective (identify which level predominates: local, national, supra-national or European?), taking into consideration that many analysts today perceive a distinct weakening of the national level (Laredo and Mustar, 2001);
- the boundary between the public and private sectors; for instance, universities could be considered either essentially as public actors or as private entrepreneurs (Etzkowitz and Leydesdorff, 2000);
- the predominant organizational frame that connects different actors: from complete independence in the pure academic form to interdependence in the network form;
- the mediators in charge of networking the different worlds (Callon, 1991), from occasional contact to integration when the state is the main "entrepreneur" in science-industry relations;
- the definition of the competences and common good to be produced that help to identify the criteria for success and the goals to be achieved;
- the institutions (rules) that frame, drive and evaluate researchers' work, with a view to fostering innovation;
- the modes of financing, from public funds (for basic research) to a web of public and private financing in the case of a network;
- the rules governing the circulation and employment of people (the type of labour market).

These conventions seek to account for the ideal-types underlying collective policy-making, rather than directly for the structural coherences of a particular country or region.

Societal constructions emerge over time from the arrangements (which vary in time and space) amongst these different approaches to policy-making. It is therefore necessary to highlight the tensions, conflicts and compromises that trigger changes in public institutions and are spurred by attempts at reform. Their degree of success is determined by the interactions between inherited historical constructions and the projects of (new) actors involved in the definition of the common good.

The characteristics of the four conventions of policy-making in science and innovation can be summarised in terms of their integration into an action regime.

TABLE 1 –THE CHARACTERISTICS OF POLICY-MAKING CONVENTIONS IN THE FIELDS OF R&D AND INNOVATION

Relevant dimensions	I Republic of science	II The state as entrepreneur	III The state as regulator	IV The state as facilitator
Overriding principle: research ethic	Scientific progress	State service and national interest	Market: shareholder value	Project: technological creativity
Level of state regulation	Discipline-based community (local faculty)	National	Regional integration ("Europe")	Multi-level
Governance of the public-private relationship	Independence of academic communities	Control by central state: ministry or agency	Co-determination of the entrepreneurial university and firms	Delegation of responsibility for technico-scientific coordination (network of agencies)
Organizational architecture	Academia (faculties)	Large programme (hierarchical management and organization)	Contract (negotiation between individuals or organizations)	Network (interaction and alignment within the network)
Category of mediating actors	Renowned scientific personalities	Managerial and political elites	Mobile scientists between the private and public organisations	Diversity of actors acting as intermediaries between university and firms
Type of competences concerned	Disciplinary knowledge	Meritocratic excellence	Operational versatility of individuals	Inter-disciplinary and ability to cooperate
Incentive institution	Peer evaluation (disclosure and priority norms)	Hi-tech objects and infrastructure	Property rights, patents and profit-sharing	Salary increases and stock options
Funding institution	Public grants and individual rights	Public programmes and markets	Joint contribution of higher education and firms	Multiplicity of sources and levels of financing
Labour institution	Occupational labour markets	Public and private internal markets	External labour markets	Labour markets peculiar to networks

The Republic of Science

The "Republic of Science" is based on a convention similar to the model of Merton, the founder of the sociology of science. It highlights the positive role of science in society and aims for "the development of codified certified knowledge" (Merton, 1973). It implies a strict separation between scientific institutions and those governing the rest of society. In this model public intervention can acquire legitimacy only by adhering to guidelines and priorities defined independently by scientists whose reputation sets the standards for competencies. This conception of the "academic state" limits public intervention to the financing of the pure public good that scientific knowledge is supposed to be. These characteristics imply the complete application of a "disclosure norm" for scientific progress (the "open science" model), after peer validation. Government has to ensure that "generic" resources are made available to society. It is up to firms to "endogenize" them, that is, to appropriate them efficiently, in a specific way. The other side to the "Republic of Science" is therefore the "Kingdom of Technology" (Polanyi, 1962), founded on a private appropriation by each agent of this general, abstract knowledge, for the purpose of generating comparative financial advantages from the efficient application of new knowledge. This radical distinction between pure research and the pursuit of industrial and economic objectives causes relations between universities and industry to depend on personalities in academia who act as advisors on the efficient application of knowledge. These relations remain occasional and informal and even tend to be hidden, for the purpose of maintaining science's original purity.

The "state as an entrepreneur"

This convention underlies a "mission-oriented" public policy (Ergas, 1992) corresponding to "radically innovative projects which are necessary for the pursuit of national interests". The mission concerns technological domains of strategic importance to the state. Its main features are the centralization of decision-making, the definition of objectives in government programmes, the concentration of the number of firms involved, and the creation of a specific government agency with a high level of discretionary power, responsible for operational coordination, under the supervision of a national or federal administration. The science/innovation relationship is then explicitly built in a framework of planning, on the basis of a model often referred to as "Colbertist" (Barré and Papon, 1998). This schema organizes a science/innovation twosome guided by a "higher" socio-economic order since technological policy is legitimized by its contribution to a national interest that, in this case, is confused with the state service.

The literature highlights the fact that it is a "top-down" innovation model, "suited to complex technological objects used for large public infrastructures" (Barré and Papon, *ibid.*). This convention has proved to be particularly effective for producing high-tech objects in public-sector markets (aeronautics, space, military, nuclear, telecommunications, etc.). Its organization is based on the model of the "large technological programme" that involves a public agency, a research institution and a large industrial group (or several privileged operators) supported by a set of sub-contractors. It functions according to a classical functional and pyramidal hierarchy originating in the military-industrial field. The objectives of the programme, the actors who have to participate in it, the operations and their scheduling are strictly defined *ex ante*. As part of a voluntarist and modernizing approach, this "industrial" and managerial conception is based on coordination by well-identified professions or academic elites (e.g. graduates of leading Research universities or French *grandes écoles*) and by applied research laboratories administered directly to help with the implementation of government policies. Meritocratic excellence is based on selection for admission to the best schools and universities, which in turn regulates access to the typically French "*grands corps de l'Etat*". These combine the technical skills and organizational capacities that lie at the interface between government administration and large firms, with a view to running the large technological programmes.

The "state as a regulator"

This convention promotes the transfer of scientific results to the private sector. It also ensures that the objectives of basic research are inspired or structured by the expectations of the "market". Whereas the convention "the state as an entrepreneur" was limited to a national scale, here there is openness to supranational horizons due to the increasing weight of multinationals in technological dynamics. The quality of public research and its partnerships with the private sector are becoming key arguments in attesting to the attractiveness of the country on a national and local level. Therefore the role of this convention is to guarantee an efficient and satisfactory balance between the use of public research resources and market dynamics. This balance implies that the governance of the public-private relationship is co-determined by partnerships between firms and entrepreneurial universities, via contracts negotiated between the partners. As a regulator, the state has to guarantee the balance of commitments.

This predominantly market orientation characteristic is confirmed by the importance given to the definition of the "property rights" that frame and stimulate two types of initiative emblematic of this convention: the creation of high-tech start-ups by academic scientists (or researchers in industry), and the development of contractual relations between universities and firms. This construction of the common good is justified theoretically in the "Mode 2" of knowledge production (Gibbons, 1994). This "new" Mode 2, focused on solving the problems as defined by industry, is based on a repeated reconfiguration of human resources in flexible forms of organization of R&D, in order to be able to adjust to market trends – an ability based on the creation of knowledge of a transdisciplinary nature (Lam, 2001). It thus aims politically to legitimize a narrowing of the gap between the academic world and enterprise, and is clearly open to a commercialisation of science (Shinn, 2002).

Efficient competencies stem from a co-production of private and public research laboratories. This co-production is supported institutionally by a contract which organizes the collaboration

between public and private-sector researchers. The generally short-term mobility of scientists between the two worlds and the co-production of PhDs help to build the trust needed to meet contractual objectives. A hybrid labour market is thus created between the higher education system and the industrial system, based on a joint construction of generic knowledge that is useable both commercially and industrially (Lanciano and Nohara 2003).

The "state as a facilitator"

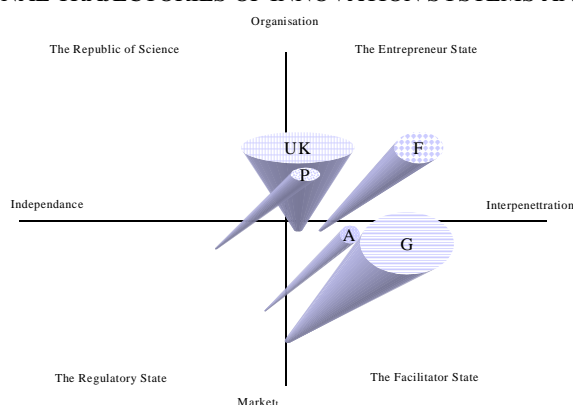
In the past ten years the literature on the economics of science and innovation has emphasized the importance of interactions between the different partners in scientific and technical production: government higher education or research institutions, firms with their own R&D capacities, and organizations involved in funding and intermediation amongst these different "spaces". This articulation has been systematized by the "Triple Helix" school (Etzkowitz and Leydesdorff *ibid.*). This type of interdependency is said to generate trilateral networks through the overlapping of the different institutional spheres and the emergence of hybrid organizations at the interfaces. The objective is to create an innovative environment consisting of firms that are university or research organization spin-offs, of tripartite initiatives for knowledge-based economic development, of strategic alliances between firms of different sizes and technological levels, of public laboratories, and university research teams. By promoting both the establishment of R&D organizations that transcend traditional institutional boundaries (public/private, academic/applied, etc.), and the creation of scientific and industrial poles at local level (Porter 1998), these public interventions seem to correspond to a logic of organized accumulation of knowledge and the creation of innovative capacities at the micro-, meso- and macro-economic levels. The dynamics of this model imply organisational internal transformations in each of the three spheres, as well as the intensification of their interrelations.

This conception of the common good calls for the creation of cooperative research networks that group together the institutionally diverse partners (Callon, 1991). The collective construction of the common good can be concretised in two ways, depending on the degree of state involvement. The first relates to those more or less spontaneous creations which gradually result from local interactions. They do not correspond to clearly defined identities and rarely have clearly identified boundaries. The second results from state initiatives that, in the name of the proclaimed efficiency of cooperative scientific networks, are designed to catch up with the level of rival technological clusters. Without being exclusive, the local (or regional) dimension is strongly present in the structure of the science or technology district (Saxenian, 1996).

IV - National trajectories of innovation systems and policy-making

Within the scope of the present article, we do not attempt to account for all the results achieved. First we sketch the compromises between the different policy making conventions that underly each national regime. Thus the relations between firms and Universities are rooted in this provisory framework. Second, we analyse the lines on which each national regime is changing via the interaction between the R&D trajectories of the firms – including new collaborations with the universities - and the evolution of the public policies.

FIGURE 1: NATIONAL TRAJECTORIES OF INNOVATION SYSTEMS AND POLICY-MAKING



The inherited national institutional frameworks should not be viewed as purely negative constraints on the micro-economic actors, but rather as available resources tending to privilege a particular type of science-industry relations.

This “non deterministic path dependency” approach (Casper, 1999) is all the more necessary, since the dynamism of RDI trajectories is becoming increasingly dependent on the emergence of innovation networks circulating tacit forms of knowledge. These networks are often backed up by various institutional arrangements such as clusters, technological districts or innovative environments in general. It is on these lines that public policies have attempted to stimulate regional initiatives (Lundvall, Borras, 1997). This approach also involves various institutional arrangements, from clusters of technological districts to more widespread innovative milieus. In fact public policy-makers have been striving to achieve this by encouraging local initiatives on these lines. This trend toward the “facilitator State convention” is combined with a stronger requirement for a more efficient valorisation of basic research. This combination shapes a new compromise peculiar to each country. Based on the systems of classification proposed by Amable, Barré and Boyer (1997) and on our empirical research, the SESI project points out some challenges and future trends which must be dealt with carefully by the policy makers of each nation:

- Traditionally, the British RDI regime has been characterized by a dual position:
 - a very strong influence from the Republic of Science, especially in the medical research and biological fields, partly because many US firms have been long established in the UK to exploit that scientific potential ("Technology Kingdom");
 - a strong engagement of the "state as an entrepreneur" in the defence industry and as a decisive factor in technological independence (computer technology in particular).

Through various reforms and new managerial practices, the British national regime of RDI is evolving towards:

- . market valorization of scientific results throughout the 1980s and 1990s spurred on by the withdrawal of the state that resulted in drastic cuts in funding, the cancellation of large national programmes and the privatization of public research laboratories;
- . the emergence of techno-scientific networks in the form of university-industry consortia and technology districts (clusters).

- Previously, the assets of German industry stemmed from the proximity of higher education, especially the Fachhochschulen (technical universities) to industry, via research companies situated at the interface between these two worlds. The efficiency of these professional networks has been proven in all capital good industries, through the regular production of incremental innovations which explain the high product quality and their ability to meet customers' needs. But both state authorities and the business community no longer believe that this situation is enough to maintain the competitive position of the German economy. The results of new public incentives appear most tangible in the biotechnology field where the number of start-ups and the use of venture capital have increased substantially – so much so that Germany is becoming the leader in this respect.

- The French higher education and research system is confronted with a profound challenge to the "state as an entrepreneur" convention that has prevailed until now (Laredo and Mustar, 2001). Public intervention is traditionally structured around large programmes. This "state as an entrepreneur" convention has also been altered internally which has strongly undermined its efficiency. The 12 July 1999 blueprint law on research and innovation is designed to promote the development of high-tech companies based on public research results under the paradoxical umbrella of the state agencies.

- Austria and Portugal, which have rather different technological and industrial structures, are both facing the special challenge of adapting the small-scale national systems of innovation to the European Union and world-wide competition in general. For Austria, it means moving “from industrial dynamics based on incremental innovation towards a knowledge-based society”, while for Portugal it means “developing entrepreneurial universities.”

Conclusion

All the countries studied in the SESI research are taking steps to promote the dissemination to industry of the results of public research in order to stimulate private innovation. The convergent national trajectories shown in Figure 1 have been largely based on the development of an ideal-type model inspired by success stories about occurrences on the American technological and industrial scene. Studies of the socio-economics of innovation have often been quoted and summarised in national reports recommending reforms, such as those drawn up by OECD experts. These studies can have as much influence as the human protagonists responsible for innovation.

These ideas have strongly influenced the reforms adopted in the various countries throughout the second half of the 1990s. The ideal model has definitely influenced the course of public policy making quite considerably. The main risk faced is that it may favour the adoption of short-term projects by research establishments and firms, to the detriment of furthering generic knowledge which is the be-all and end-all of the Republic of Sciences. Powell and Owen-Smith (1998) have pointed out, for example, that transforming the academic system by introducing commercial criteria into the new modes of research assessment might completely undermine the research missions of universities and destroy the public authorities' confidence in them.

The present analysis of public policy making in the field of R&D and innovation (RDI) was therefore undertaken with a view to analysing the possible conditions for linking up the reforms adopted at national level with specific, local collective practices rooted in past institutional and organisational histories. Our analysis was based on four ideal-types for the construction of common goods involving both public and private actors at various levels.

The compromises and arrangements that have been put in place serve to define these evolving national regimes and show to what extent the "ideas" described above have been adapted to national contexts. The increasingly strong presence of "regulatory state" and "facilitatory state" conventions to the detriment of "entrepreneurial state" and, to a lesser extent, "republic of science" conventions has led to increasing diversification in the forms of public intervention. Public policy making has come to depend less on the national institutional framework and more on the initiatives of co-operative networks and local configurations, in which the entrepreneurial partners include multinational firms whose strategies cannot be summed up in a single overall plan of action. It has become increasingly necessary, if we want to be able to continue to refer to a single national system, to view this system as resulting from a whole set of networks and configurations which, if they hold together to form a coherent entity, do so only partly because of the direct influence of national institutions.

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